ADAPTIVE CRUISE CONTROL SYSTEM AND METHOD FOR AUTOMOTIVE VEHICLE WITH INTER-VEHICLE DISTANCE CONTROL FUNCTION

BACKGROUND OF THE INVENTION:

Field of the invention

[0001]   The present invention relates to adaptive cruise control system and method for an automotive vehicle (hereinafter, also called a host vehicle) with an inter-vehicle distance control function to follow a preceding vehicle which is traveling ahead of the host vehicle.

Description of the related art

[0002]   A Japanese Patent Application First Publication No. 2000-168395 published on June 20, 2000 exemplifies a previously proposed adaptive cruise control system. In the previously proposed vehicular cruise control system disclosed in the above-identified Japanese Patent Application First Publication, an inter-vehicle distance between the host vehicle and the preceding vehicle is detected and a cruise speed run is carried out at a constant speed (so-called, a set cruise speed) which is set by a vehicular driver of the host vehicle. For example, if the preceding vehicle becomes approached to the host vehicle or becomes spaced apart from the host vehicle so that the inter-vehicle distance is varied. At this time, the previously proposed vehicular adaptive cruise control system adjusts a braking force or a driving force of the host vehicle so that the inter-vehicle distance is made substantially equal to a target inter-vehicle distance. As described above, a vehicular running state is feedback controlled. In addition, in order to calculate the target inter-vehicle distance, for example, a traveling speed of

the preceding vehicle is detected, is multiplied by an inter-vehicle time duration, and is added to a distance to make the host vehicle stop to calculate the target inter-vehicle distance.

[0003] It is noted that the inter-vehicle distance time duration is defined as a time duration required for the host vehicle to be reached to the present position of the preceding vehicle (in other words, a time required for the host vehicle to run by a distance corresponding to the inter-vehicle distance). For example, the inter-vehicle distance time duration is previously set as about two seconds. It is also noted that the distance to make the vehicle stop corresponds to a distance left between the host vehicle and the preceding vehicle when the host vehicle stops while the preceding vehicle is stopped and is preset to, for example, 2 meters. It is also noted that since when the host vehicle is running at the constant speed at a predetermined inter-vehicle distance, viz., the target inter-vehicle distance, the traveling speed of the preceding vehicle is exactly equal to or substantially equal to that of the host vehicle, the traveling speed of the host vehicle may be used to calculate the target inter-vehicle distance.

SUMMARY OF THE INVENTION:

[0004] However, in the previously proposed cruise control apparatus disclosed in the above-described Japanese Patent Application First Publication, the feedback control is executed in such a manner that the detected inter-vehicle distance is made substantially equal to the target inter-vehicle distance. Hence, upon the detection that the inter-vehicle distance becomes different from the target inter-vehicle, an acceleration or deceleration request is issued according to a difference value thereof. Suppose herein that, for example, the target inter-vehicle distance

is set according to the traveling speed of the preceding vehicle, the preceding vehicle is decelerated. At this time, since the inter-vehicle distance becomes short and the target inter-vehicle distance also becomes short, an

5 absolute value of a vehicular deceleration demanded for the host vehicle becomes small. Consequently, the vehicular driver feels that a control response characteristic becomes worsened. This case also applies to a case where the preceding vehicle becomes accelerated. Then, since the acceleration

10 demanded for the host vehicle becomes small in the same manner as described in the case of the vehicular deceleration, so that the driver feels that the control response characteristic also becomes worsened.

[0005] A technique to improve the acceleration or

15 deceleration response characteristic can be thought to include that a feedback gain is made large which is used in the feedback control between the target inter-vehicle distance and the detected inter-vehicle distance. However, using such the technique as described above causes the

20 acceleration or deceleration during an ordinary follow run to the preceding vehicle to be excessively sensitive and a vehicular comfortability can conversely be worsened.

[0006] It is hence an object of the present invention to provide adaptive cruise control system and method for

25 an automotive vehicle with the inter-vehicle distance control function which can provide a favorable response characteristic for the acceleration or deceleration of the preceding vehicle without worsening the vehicular comfortability.

30 [0007] According to one aspect of the present invention, there is provided an adaptive cruise control system for an automotive vehicle, comprising: an inter-vehicle distance detecting section (12, 20) that detects a presence

of a preceding vehicle which is traveling ahead of the vehicle and detects an inter-vehicle distance between the vehicle and the preceding vehicle; a vehicular velocity detecting section (13L, 13R, 20) that detects a velocity of at least one of the vehicle and the preceding vehicle; a target inter-vehicle distance setting section (20) that sets a target inter-vehicle distance on the basis of at least one of the velocities of the vehicle and the preceding vehicle; a vehicular traveling speed controlling section (20) that controls a traveling state of the vehicle on the basis of the detected inter-vehicle distance and the target inter-vehicle distance; and a delay providing section (20) that provides a delay for one of the detected velocities of the vehicle and the preceding vehicle which is used to set the target inter-vehicle distance at a time of a detection of one of the velocities of the vehicle and the preceding vehicle which is used to set the target inter-vehicle distance, the target inter-vehicle distance setting section setting the target inter-vehicle distance on the basis of the detected velocity for which the delay is provided by the delay providing section.

[0008]   According to another aspect of the present invention, there is provided an adaptive cruise control method for an automotive vehicle, comprising: detecting a presence of a preceding vehicle which is traveling ahead of the vehicle; detecting an inter-vehicle distance between the vehicle and the preceding vehicle; detecting a velocity of at least one of the vehicle and the preceding vehicle; controlling a traveling state of the vehicle on the basis of the detected inter-vehicle distance and a target inter-vehicle distance; providing a delay for one of the detected velocities of the vehicle and the preceding vehicle which is used to set the target inter-vehicle distance at

a time of a detection of one of the velocities of the vehicle and the preceding vehicle which is used to set the target inter-vehicle distance; and setting the target inter-vehicle distance on the basis of the detected velocity of one of the vehicle and the preceding vehicle for which the delay is provided.

[0009]   This summary of the invention does not necessarily describe all necessary features so that the invention may also be a sub-combination of these described features.

BRIEF DESCRIPTION OF THE DRAWINGS:

[0010]   Fig. 1 is a system configuration view of a rear-wheel-drive vehicle to which an adaptive cruise control system with an inter-vehicle distance control function in a preferred embodiment according to the present invention is applicable.

[0011]   Fig. 2 is an operational flowchart of a preceding vehicle following control procedure carried out by an adaptive cruise controller shown in Fig. 1.

[0012]   Fig. 3 is a detailed flowchart of a subroutine executed at a step S5 shown in Fig. 2.

[0013]   Fig. 4 is a detailed flowchart of a subroutine executed at a step S15 shown in Fig. 3.

[0014]   Fig 5 is a detailed flowchart of a subroutine executed at a step S16 shown in Fig. 3.

[0015]   Fig. 6 is a detailed flowchart of a subroutine executed at a step S18 shown in Fig. 3.

[0016]   Fig. 7 is a detailed flowchart of a subroutine executed at a step S19 shown in Fig. 3.

[0017]   Figs. 8A, 8B, and 8C are timing charts for explaining an operation of the adaptive cruise control system in the preferred embodiment shown in Fig. 1 when the preceding vehicle which is running ahead of the host vehicle is decelerated.

[0018]   Figs. 9A, 9B, and 9C are timing charts for explaining an operation of the adaptive cruise control system in a comparative example of the adaptive cruise control system when the preceding vehicle is decelerated.

[0019]   Fig. 10 is a timing chart for explaining variation characteristics of accelerations/decelerations of both of Figs. 8A and 9A.

[0020]   Figs. 11A, 11B, and 11C are timing charts for explaining another operation of the adaptive cruise control system which is different from that shown in Figs. 8A through 8C when the preceding vehicle is decelerated.

[0021]   Figs. 12A, 12B, and 12C are timing charts for explaining another operation of the comparative example to the adaptive cruise control system which is different from that shown in Figs. 9A through 9C.

[0022]   Fig. 13 is a timing chart for explaining variation characteristics of accelerations/decelerations of both of Figs. 11A and 12A when they are overlapped on the same graph thereof.

[0023]   Fig. 14 is a detailed flowchart executed at step S15 in the case of the adaptive cruise control system in another preferred embodiment according to the present invention.

[0024]   Fig. 15 is a control map on a time constant in an LPF (low-pass filter) used in a calculation process shown in Fig. 14.

[0025]   Figs. 16A, 16B, and 16C are timing charts for explaining a still another operation of the comparative example to the adaptive cruise control system in the other preferred embodiment when the preceding vehicle is decelerated.

[0026]   Fig. 17 is a timing chart for explaining variation characteristics of accelerations/decelerations of both of

Figs. 9A and 16A when they are overlapped on the same graph thereof.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS:

[0027]   Reference will hereinafter be made to the drawings

5   in order to facilitate a better understanding of the present invention.

[0028]   Fig. 1 shows a schematic block diagram of a system configuration of a rear-wheel-drive vehicle to which an adaptive cruise control system with an inter-vehicle

10   distance control function in a preferred embodiment according to the present invention is applicable. In Fig. 1, a driving force of an engine 2 is transmitted to rear left and right road wheels (driven wheels) 1RL and 1RR via an automatic transmission 3, propeller shaft 4, a final

15   speed-reduction gear unit 5, and an wheel axel 6. In Fig. 1, reference signs of 1FL and 1FR denote non-driven wheels of front left and right road wheels.

[0029]   In addition, rear left and right road wheels 1RL and 1RR are provided with disc brakes 7 to generate braking

20   forces, respectively. A brake fluid pressures applied to these disc brakes 7 is controlled by a brake controller 8. It is noted that brake controller 8 generates the brake fluid pressure in accordance with a depression depth of a brake pedal 8a and generates the brake fluid pressure

25   in accordance with a brake fluid pressure command value issued from an adaptive cruise controller (ACC) 20.

[0030]   In addition, an engine output controller 9 is installed on engine 2 to control an output of engine 2. Two methods of engine output control can be considered.

30   That is to say, one of the methods is to control an engine speed by adjusting an opening angle of a throttle valve and another method is to control an engine idling speed of engine 2 by adjusting an opening angle of an idle control

valve of engine 2. In the preferred embodiment, the former method of controlling the engine speed by adjusting the opening angle of the throttle valve is adopted.

[0031]   An inter-vehicle distance sensor 12 is installed on a front lower part of a vehicle body of the host vehicle which is constituted by a radar unit (inter-vehicle distance detecting section) which detects a presence of a preceding vehicle which is traveling ahead of the host vehicle and detects an inter-vehicle distance from the host vehicle to the preceding vehicle. In addition, wheel speed sensors 13L and 13R are disposed to detect wheel velocities of the rear left and right road wheels 1RL and 1RR.

[0032]   Furthermore, each output signal of inter-vehicle distance sensor 12, wheel speed sensors 13L and 13R, and a brake pedal switch 14 is inputted to adaptive cruise controller 20. Adaptive cruise controller 20 controls brake controller 8 and engine output controller 9 on the basis of the inter-vehicle distance D and wheel velocities Vw_{RL} and Vw_{RR} detected by wheel speed sensors 13L and 13R. Hence, adaptive cruise controller 20 executes a steady-state preceding vehicle following control which makes the host vehicle follow the preceding vehicle maintaining an appropriate inter-vehicle distance between the host vehicle and the preceding vehicle and controls a vehicular running state by accelerating or decelerating the host vehicle in response to the acceleration or deceleration of the preceding vehicle.

[0033]   Next, a calculation procedure for the preceding vehicle following control to be executed by adaptive cruise controller 20 will be described with reference to an operational flowchart shown in Fig. 2.

[0034]   The calculation process shown in Fig. 2 is a timer interrupt routine executed whenever a predetermined control

period of time $\triangle T$ (for example, 10 milliseconds) has passed. It is noted that each controller 8, 9, and 20 includes a microcomputer CPU (Central Processing Unit), ROM (Read Only Memory), RAM (Random Access Memory), Input Port, Output Port, a timer, a timer controller, and a common bus. It is noted that although, in the flowchart shown in Fig. 2, steps to communicate with the other controller are not provided, for example, any information obtained from the flowchart is stored at any time into a storage device such as RAM and the required information is read from the storage device. In addition, each controller 8, 9, and 20 performs a mutual communication and the required information is always read from any one of the controllers 8, 9, 20 which performs a management of all controllers. The supplied information is at any time stored into the corresponding storage device.

[0035]   Referring to Fig. 2, at a step S1, adaptive cruise controller 20 reads an actual inter-vehicle distance D detected by inter-vehicle distance sensor 12 between the host vehicle and the preceding vehicle. At the next step S2, adaptive cruise controller 20 calculates a relative velocity Vr between the host vehicle and the preceding vehicle from a variation rate between the presently read inter-vehicle distance D at step S1 and a previously read inter-vehicle distance D thereat. At the next step S3, adaptive cruise controller 20 calculates the vehicular velocity of the host vehicle from an average value between the road wheel velocities Vw_{RL} and Vw_{RR}. Then, the routine goes to a step S4, adaptive cruise controller 20 reads set vehicle speed Vs set by the driver. At the next step S5, adaptive cruise controller 20 calculates a target acceleration/deceleration in accordance with a calculation process as will be shown in Fig. 3.

[0036]   At the next step S6, adaptive cruise controller

20 implements an acceleration/deceleration control using
engine 2 and brake system via engine controller 8 and brake
controller 9 in accordance with individual calculation
processes (not shown) and the routine shown in Fig. 2 is

5   returned to a main routine.

[0037]   Next, Fig. 3 shows a detailed flowchart executed
at step S5 in Fig. 2. At a first step S11, adaptive cruise
controller 20 determines whether the preceding vehicle has
been detected in accordance with an individual calculation

10   process (not shown). If the preceding vehicle has been
detected (Yes) at step S11, the routine goes to a step S15.
If No at step S15, the routine goes to a step S17.
At step S15, adaptive cruise controller 20 calculates a
target inter-vehicle distance D* in accordance with a

15   calculation process shown in Fig. 4 and the routine goes
to a step S16.

[0038]   At step S16, adaptive cruise controller 20
calculates an inter-vehicle distance priority target
acceleration/deceleration G_D from target inter-vehicle

20   distance D* and actual inter-vehicle distance D in
accordance with a calculation process shown in Fig. 5.   Then,
the routine goes to a step S17.

[0039]   At step S17, adaptive cruise controller 20
calculates a target vehicular velocity Vc* (target velocity

25   of the host vehicle) and the routine goes to a step S18.
The target vehicular velocity Vc* is set so that the host
vehicle velocity Vc is increased at a constant acceleration
to the set vehicle speed Vs when the host vehicle velocity
Vc calculated as shown in Fig. 2 is smaller than set vehicle

30   speed Vs. If not, the set vehicular velocity Vs is directly
set to target vehicular velocity Vc*. At step S18, adaptive
cruise controller 20 calculates a vehicular velocity
priority target acceleration/deceleration Gv from target

vehicular velocity Vc* and vehicular velocity Vc in accordance with the calculation process shown in Fig. 6 as will be described later. Then, the routine goes to a step S19. At step S19, adaptive cruise controller 20 selects

5   target acceleration/deceleration G* in accordance with a calculation process shown in Fig. 7 as will be described later.

[0040]   Next, the calculation process in Fig. 4 executed at step S15 in Fig. 3 will be described below. At a step

10   S15a, adaptive cruise controller 20 reads the host vehicle velocity Vc calculated at step S3 shown in Fig. 2. At the next step S15b, adaptive cruise controller 20 reads the relative velocity Vr calculated at step S2 shown in Fig. 2.

15   [0041]   At a step S15c, adaptive cruise controller 20 adds the host vehicular velocity Vc read at step S15a to the relative velocity Vr read at step S15c calculated at step S15b to calculate a velocity V_F of the preceding vehicle. At the next step S15d, adaptive cruise controller 20

20   determines if velocity of the preceding vehicle V_F calculated at step S15c is equal to or smaller (lower) than a first predetermined velocity value of 40 Km/h. If Yes at step S15d, the routine goes to a step S15e. If No at step S15, the routine goes to a step S15f. At step S15f,

25   adaptive cruise controller 20 determines if velocity of the preceding vehicle V_F is equal to or smaller than a second predetermined velocity value of 50 Km/h. If Yes at step S15f, the routine goes to a step S15g. If No at step S15f, the routine goes to a step S15h. At step S15h, adaptive

30   cruise controller 20 determines whether velocity V_F of the preceding vehicle is equal to or smaller than a third predetermined value of 60 Km/h. If Yes at step S15h, the routine goes to a step S15i.   If No at step S15h, the routine

goes to a step S15j. At step S15j, adaptive cruise controller 20 determines if velocity of the preceding vehicle V_F is equal to or smaller than a fourth predetermined value of 70 Km/h. If Yes at step S15j, the routine goes to a step

5   S15k. If No at step S15j, the routine goes to a step S15m. At step S15m, adaptive cruise controller 20 determines if velocity of the preceding vehicle V_F is equal to or smaller than a fifth predetermined value of 80Km/h, If Yes at step S15n, the routine goes to a step S15n. If No at step S15m,

10   the routine goes to a step S15p.

[0042]   At step S15e, adaptive cruise controller 20 sets the velocity of the preceding vehicle fifth control number of times before the present time V_{F5} to a delay processed velocity of the preceding vehicle V_{FF}.   At step S15g,

15   adaptive cruise controller 20 sets velocity of the preceding vehicle fourth control numbers of times before the present time V_{F4} to delay processed velocity of the preceding vehicle V_{FF}. At step S15i, adaptive cruise controller 20 sets the velocity of the preceding vehicle third control

20   number of times before the present time V_{F3} to delay processed velocity of the preceding vehicle V_{FF}. At step S15k, adaptive cruise controller 20 sets velocity of the preceding vehicle twice numbers before the present time to the delay processed vehicular velocity of the preceding vehicle V_{FF}. At step

25   S15p, adaptive cruise controller 20 sets the present vehicular velocity of the preceding vehicle V_{FF} to the delay processed vehicular velocity of the preceding vehicle V_F.

[0043]   At a step S15q, adaptive cruise controller 20 calculates target inter-vehicle distance D*by multiplying

30   delay processed velocity of the preceding vehicle V_{FF} by an inter-vehicle time duration α and by adding the result of multiplication to a predetermined distance β during the stop of the host vehicle $(D*= \alpha \times V_{FF} + \beta)$. It is noted that

numerical values for the inter-vehicle velocity α and the distance during the vehicular stop β are used for those described above. At the next step S15r, adaptive cruise controller 20 updates the vehicular velocity of the preceding vehicle V_{F5} through V_F as follows: $V_F \rightarrow V_{F1}$, $V_{F1} \rightarrow V_{F2}$, $V_{F2} \rightarrow V_{F3}$, $V_{F3} \rightarrow V_{F4}$, and $V_{F4} \rightarrow V_{F5}$. Then, the routine goes to step S16 shown in Fig. 3.

[0044]   Fig. 5 shows the detailed flowchart of the calculation process of step S16 shown in Fig. 3.

[0045]   At a step S16a, adaptive cruise controller 20 calculates a difference $\triangle D$ between target and actual inter-vehicle distances $(\triangle D = D - D*)$. At the next step S16c, adaptive cruise controller 20 calculates inter-vehicle distance priority target acceleration/deceleration G_D by multiplying difference $\triangle D$ of the inter-vehicle distance calculated at step S16a by a predetermined gain F_1 $(G_D = F_1 \times \triangle D)$. Then, the routine goes to step S17 shown in Fig. 3.

[0046]   Next, Fig. 6 shows a detailed flowchart of step S18 shown in Fig. 3.

[0047]   At a step S18a, adaptive cruise speed controller 20 calculates a difference $\triangle Vc$ in the vehicular velocity between target vehicular velocity V* calculated at step S17 shown in Fig. 3 from the host vehicular velocity Vc calculated at step S3 of the calculation process at step S3 shown in Fig. 2. At a step S18a, adaptive cruise speed controller 20 calculates vehicular velocity priority target acceleration/deceleration G_V from a total sum of a value of the vehicular velocity difference $\triangle Vc$ multiplied by a proportional gain Kp, an integration value of the vehicular velocity difference $\triangle Vc$ multiplied by a differential gain Ki, and a differential value of the vehicular velocity difference $\triangle Vc$ multiplied by a differential value Kd

($G_v = (Kp + Ki/s + Kds)\triangle Vc$). Then, the routine goes to step S19 shown in Fig. 3. It is noted that s denotes a differential operator.

[0048] Fig. 7 shows a detailed flowchart of step S19 shown in Fig. 3.

[0049] At a step S19a, adaptive cruise controller 20 determines whether the preceding vehicle has been detected in accordance with an individual calculation process (not shown). If the preceding vehicle has been detected at step S19a, the routine goes to step S19c. If No at step S19a, the routine goes to a step S19b. At step S19c, adaptive cruise controller 20 determines if the host vehicle is running at set vehicle speed Vs according to whether the host vehicle velocity is substantially equal to or is approximated to the set vehicle speed Vs. If Yes at step S19c, adaptive cruise controller 20 sets the vehicular velocity priority target acceleration/deceleration Gv calculated at the step S18 shown in Fig. 6 to the target acceleration/deceleration G* and the routine goes to step S6 shown in Fig. 2 (G* = G_v). At step S19d, adaptive cruise controller 20 sets either one of inter-vehicle distance priority target acceleration/deceleration G_D calculated at the calculation process shown in Fig. 5 or the vehicular velocity priority acceleration/deceleration Gv calculated at the calculation process shown in Fig. 6 whose absolute value is smaller to target acceleration/deceleration G* and goes to step S6 of the calculation process shown in Fig. 2.

[0050] According to the above-described series of processes, relative velocity Vr is calculated at the next step S2 from inter-vehicle distance D read at step S1 of the calculation process shown in Fig. 2. At the step S3, the host vehicle velocity Vc is calculated from wheel

velocities Vw_{RL} and Vw_{RR} and the set vehicular velocity Vs is read at step S4, and the target acceleration/deceleration $G*$ is carried out at step S5 so that the acceleration/deceleration control at step S6 is carried

5 out according to the determined target acceleration/deceleration.

[0051]   In order to calculate the target acceleration/deceleration $G*$, the presence or absence of the preceding vehicle is determined at step S11 of the

10 calculation process shown in Fig. 3. If the preceding vehicle is present, target inter-vehicle distance $D*$ is calculated in accordance with the calculation process shown in Fig. 4 carried out at step S15. Then, inter-vehicle distance priority acceleration/deceleration G_D is calculated in

15 accordance with the calculation process shown in Fig. 5 carried out at step S16 from the difference value between target inter-vehicle distance $D*$ and actual inter-vehicle distance D. On the other hand, if no preceding vehicle is present, the above-described inter-vehicle distance

20 priority target acceleration/deceleration G_D is not calculated. Target vehicular velocity $Vc*$ at step S17 of Fig. 3 is calculated. Vehicular velocity priority acceleration/deceleration Gv is calculated in accordance with the calculation process shown in Fig. 6 carried out

25 at step S18 from the difference value between target vehicular velocity $Vc*$ and actual host vehicular velocity Vc. It is noted that, in a case where the preceding vehicle is present, vehicular velocity priority target acceleration/deceleration Gv is calculated in the same

30 manner as described above. Then, according to the calculation process shown in Fig. 7 carried out at step S19 of the calculation process shown in Fig. 3, if the preceding vehicle is present and the vehicle is not running

at the set vehicle speed Vs , either one of the inter-vehicle distance or the vehicular velocity priority target acceleration/deceleration G_D or G_V whose absolute value is smaller than the other is the final

5   acceleration/deceleration G*. If the preceding vehicle is not present or the vehicle is running at the set vehicle speed Vs, the vehicular velocity priority target acceleration/deceleration G_V is the final target acceleration/deceleration G*. Hence, when the host

10   vehicle is running to follow the preceding vehicle, the acceleration or deceleration is controlled so that an appropriate inter-vehicle distance can be maintained in accordance with the velocity of the host vehicle. On the other hand, if the host vehicle is not following the preceding

15   vehicle, the control priority is taken on set vehicle speed Vs to control the acceleration/deceleration of the host vehicle.

[0052] It is noted that target inter-vehicle distance D* used to calculate inter-vehicle distance priority

20   target acceleration/deceleration G_D is calculated in accordance with the calculation process shown in Fig. 4 carried out at step S15 of calculation process shown in Fig. 3. In this calculation process, target inter-vehicle distance D* is calculated using the preceding vehicle

25   velocity V_F in principle. However, delay processed preceding vehicle velocity V_{FF} used to calculate target inter-vehicle distance D* has a larger delay as the preceding vehicle velocity V_F becomes lower.

[0053] In details, if preceding vehicle velocity V_F is

30   equal to or lower than 40 Km/h, the vehicular velocity V_F of the preceding vehicle fifth number of times in control number of times before the present velocity V_F of the preceding vehicle, i.e., fifth number of times previously

detected preceding vehicle velocity V_F is set to delay processed preceding vehicular velocity V_{FF}. In the similar manner, if the preceding vehicle velocity V_F is equal to or lower than 50 Km/h but in excess of 40 Km/h, velocity

5   V_F of the preceding vehicle fourth number of times in control number of times before the present velocity V_F of the preceding vehicle, i.e., fourth number of times previously detected preceding vehicle velocity V_{F4} is set to delay processed preceding vehicular velocity V_{FF}.

10   [0054]   If 50 Km/h $<$ V_F $\leqq$ 60 Km/h, the preceding vehicle velocity third number of times in control number of time before the present preceding velocity, i.e., three times previous preceding vehicle velocity V_{F4} is set to the delay processed preceding vehicle velocity V_{FF}. If 60 Km/h $<$ V_F

15     $\leqq$ 70 Km/h, the preceding vehicle velocity V_F twice in control number of times before the present preceding vehicle velocity V_F is set to delay processed preceding vehicle velocity V_{FF}. If 70 Km/h $<$ V_F $\leqq$ 80 Km/h, the preceding vehicle velocity V_F one number of times (once) previous preceding

20   vehicle velocity V_{F1}, i.e., the previous preceding vehicle velocity is set to delay processed preceding vehicle velocity V_{FF}. These series of processes mean that, even if the preceding vehicle velocity V_F is varied due to the acceleration or deceleration of the preceding vehicle,

25   delay processed preceding vehicle velocity V_{FF} is used in stead of present preceding vehicle velocity V_F so that a variation in target inter-vehicle distance $D*$ is delayed (since the control time duration is very short, the delay is slight). As described in the preferred embodiment, in

30   such a case where a feedback control as to make actual inter-vehicle distance D substantially equal to target inter-vehicle distance $D*$ is performed, difference value $\triangle D$ between target inter-vehicle distance $D*$ and actual

inter-vehicle distance D is small as its absolute value
as compared with no delay case or is a value in an opposite
direction to the difference value obtained in the case of
no delay. In other words, even if the difference value in
5   nature is a positive value, a negative value is often obtained.
Even if the difference value in nature is a positive value,
a negative value is often obtained.

[0055]   For example, although, due to the deceleration
of the preceding vehicle target inter-vehicle distance D*
10   is short, the actual inter-vehicle distance D is longer
than target inter-vehicle distance D*. At this time,
difference value $\triangle$D of target inter-vehicle distance value
D? D^* from actual inter-vehicle distance D indicates a
positive value. As described above, since difference value
15   $\triangle$D of target inter-vehicle distance D* from actual
inter-vehicle distance D indicates a positive value. As
described above, since difference value $\triangle$D between target
inter-vehicle distance D* and actual inter-vehicle distance
D is represented by a positive value, actual inter-vehicle
20   distance D is shortened. Hence, it is not necessary to
decelerate at least so large at any more or it is not necessary
to decelerate too large even if decelerated.

[0056]   However, when target inter-vehicle distance D*
is calculated using delay processed preceding vehicular
25   velocity V_{FF} in place of the present preceding vehicle
velocity as described above, target inter-vehicle distance
D* is calculated using delay processed preceding vehicular
velocity as described above, target inter-vehicle distance
D* is calculated using delay processed preceding vehicle
30   vehicular velocity V_{FF}. At this time, target inter-vehicle
distance D* is calculated using delay processed preceding
vehicle vehicular velocity V_{FF}. At this time, target
inter-vehicle distance D* becomes larger than the original

value. Hence, a difference value $\triangle D$ between target inter-vehicle distance D* and actual inter-vehicle distance D becomes larger than the original value or negative value. Hence, it becomes necessary to maintain the inter-vehicle

5 distance or to elongate the inter-vehicle distance. Consequently, a deceleration demand appears at an earlier timing so that a response characteristic to the deceleration control of the vehicle to the deceleration of the preceding vehicle becomes favorable.

10 [0057] In addition, since target inter-vehicle distance D * becomes long due to the deceleration of the preceding vehicle, difference value $\triangle D$ of target inter-vehicle distance D* subtracted from actual inter-vehicle distance D indicates a negative value. The negative value of the

15 difference value $\triangle D$ directly indicates the elongation of the actual inter-vehicle distance D. It is not at least necessary to be accelerated so largely since the actual inter-vehicle distance D is made long. Or it is not necessary to largely accelerate even if accelerated. As

20 described above, if target inter-vehicle distance D*is calculated using delay processed preceding vehicular velocity V_{FF} in place of the preceding vehicle velocity V_F. Since target inter-vehicle distance D* is made shorter than the original value, difference value $\triangle D$ between target

25 inter-vehicle distance D* and actual inter-vehicle distance D is made larger than the original value, the inter-vehicle distance is maintained constant, or shortened, the acceleration demand appears at an earlier timing. Consequently, the response characteristic of acceleration

30 control to the acceleration of the preceding vehicle becomes favorable.

[0058] Figs. 8A through 8C show timing charts of inter-vehicle distance priority target

acceleration/deceleration G_D, inter-vehicle distance $D*$, preceding vehicle velocity V_F, and delay processed preceding vehicle velocity V_{FF} in the case of the preferred embodiment of the adaptive cruise control system when the preceding vehicle is decelerated from 30 Km/h to 0 Km/h, viz., to the stopped state.

[0059]   Since, in the preferred embodiment, for the preceding vehicle V_F which is equal to or lower than 40 Km/h at the calculation process of Fig. 4, the delay is the largest since the fifth number of times previously detected preceding vehicle velocity V_{FF} is always set to delay processed preceding vehicle velocity V_{FF}.   .

[0060]   Hence, with respect to the preceding vehicle V_F which is decelerated at a constant gradient, the delay processed preceding vehicle V_{FF} is delayed as if delay processed preceding vehicle velocity V_{FF} were shifted in parallel thereto. Hence, target inter-vehicle distance $D*$ is accordingly retarded in the same way as delay processed preceding vehicle velocity V_{FF}. On the other hand, since actual inter-vehicle distance D becomes shorter than target inter-vehicle distance $D*$ immediately after the preceding vehicle is decelerated, the difference value ΔD of target inter-vehicle distance $D*$ subtracted from actual inter-vehicle distance D indicates negative.

[0061]   At this time, it becomes necessary to elongate the inter-vehicle distance described above. Hence, the deceleration demand comes at the earlier time. Consequently, the deceleration at the initial stage of the control becomes large and the response characteristic of the vehicular deceleration control becomes favorable.

[0062]   Figs. 9A, 9B, and 9C show timing charts of inter-vehicle distance priority target acceleration G_{DO}, the inter-vehicle distance D, and target inter-vehicle

distance D^*_0, preceding vehicle velocity V_F, and delay processed preceding vehicle velocity V_{FF} in a case of a comparative example in which when no delay process of the preceding vehicle vehicular velocity V_F is carried out when

5 the preceding vehicle is decelerated in the same way as Figs. 8A, 8B, and 8C. In this case, since actual inter-vehicle distance D is always larger than the target inter-vehicle distance D^*_0, the difference value $\triangle D$ of subtraction of target inter-vehicle distance D^*_0 from actual inter-vehicle

10 distance D is positive. Hence, since actual inter-vehicle distance D is shortened, it is not at least necessary to decelerate as yet. Or it is not necessary to decelerate the vehicle not so largely. This provides a cause of a dull response characteristic of deceleration control.

15 [0063] Fig. 10 shows a timing chart in which only (inter-vehicle distance priority) target acceleration G_D in the preferred embodiment of the adaptive cruise control system and inter-vehicle distance priority target acceleration/deceleration G_{D0} in the case of the comparative

20 example are mutually overlapped on the same graph. As shown in Fig. 10, immediately after the deceleration start of the preceding vehicle, absolute value of the inter-vehicle distance priority target acceleration/deceleration G_D in the preferred embodiment is larger than the inter-vehicle

25 distance priority target acceleration/deceleration G_{D0} in the case of the comparative example and the response characteristic of the deceleration control becomes favorable.

[0064] On the other hand, at the latter half stage of

30 deceleration control, the absolute value of inter-vehicle distance priority target acceleration/deceleration G_D in the preferred embodiment is smaller than inter-vehicle distance priority target acceleration/deceleration G_{D0} in

the case of the comparative example and the deceleration control is smoothly converged. In this embodiment, it is not necessary to enlarge the feedback gain. Hence, there is almost no case where the acceleration/deceleration is too sensitive during the ordinary preceding vehicle following control run and the comfortability is worsened.

[0065] In the preferred embodiment, as the preceding vehicle velocity V_F becomes lower, the delay becomes larger. In other words, since a dead time to be added to preceding vehicle velocity V_F becomes larger, the deceleration request becomes accordingly faster, an initial response becomes more favorable as the velocity of the preceding vehicle becomes lower so that the deceleration characteristic accommodated to the driver's intention can be obtained. In addition, at the high speed run, the initial response is suppressed. No uncomfortable feeling is given to the vehicular occupant in the host vehicle during such a high-speed run that the deceleration is smooth.

[0066] In addition, in the preferred embodiment, no delay is provided for during the host vehicular run at the high speed in excess of 80 Km/h. That is to say, since the response characteristic of deceleration is suppressed during the high-speed run, no uncomfortable feeling is given to the vehicular occupant. A reverse effect appears during the acceleration of the preceding vehicle in the similar manner as described above. In details, since the response characteristic to the deceleration is suppressed during the high speed run, no uncomfortable feeling is given during the high speed run at which the deceleration is smooth. It is noted that the reverse effect of this fact appears during the acceleration of the preceding vehicle as described above.

[0067] In addition, as described above, when the host

vehicle is running to follow the preceding vehicle, the vehicular velocity of the host vehicle is equal to or substantially equal to each other, the vehicular velocity of the host vehicle Vc may be used to calculate target

5   inter-vehicle distance D*. In this case, an object to which the delay is added is the velocity of the host vehicle Vc. Figs. 11A, 11B, and 11C show timing charts of (inter-vehicle distance priority target) acceleration/deceleration G_D, inter-vehicle distance D, and target inter-vehicle distance

10   D*, host vehicle velocity Vc, and delay processed host vehicular velocity Vc_F when the host vehicle is decelerated from 30 Km/h to 0 km/h (namely, the host vehicle is decelerated to the vehicle stopped state) in the same way as shown in Figs. 8A, 8B, and 8C.

15   [0068]   The delay process for the vehicular velocity of the host vehicle Vc in the preferred embodiment is executed in such a way that an object to be delay processed in the calculation process of Fig. 4 is exchanged from the preceding vehicle velocity V_F to vehicular velocity Vc and the delay

20   time to be added to the host vehicular velocity is gradually increased with the decrease in the host vehicular velocity Vc.   Hence, a delay processed host vehicular velocity V_{CF} is largely delayed with a gradient of deceleration gradually reduced with respect to the host vehicular velocity Vc

25   gradually reduced at a gradient of a substantially constant value together with the deceleration of the preceding vehicle.

[0069]   Target inter-vehicle distance D* in accordance with delay processed host vehicular velocity V_{CF} is largely

30   delayed in the same manner as delay processed host vehicle velocity V_{CF}. Whereas, since actual inter-vehicle distance D is always considerably small value as compared with target inter-vehicle distance D*, the absolute value of difference

value $\triangle D$ indicates a large value of a negative value. At this time, as described above, the inter-vehicle distance needs to quickly be elongated. Hence, the deceleration request appears quickly. Consequently, the deceleration

5 at the initial stage of control becomes large so that the response characteristic to the deceleration control of the host vehicle becomes favorable.

[0070] Figs. 12A, 12B, and 12C show timing charts representing (inter-vehicle distance priority target)

10 acceleration/deceleration G_{D0} of the comparative example when target inter-vehicle distance $D*_0$ is calculated from host vehicle velocity Vc, inter-vehicle distance D, target inter-vehicle distance $D*_0$, host vehicular velocity Vc, and delay processed host vehicular velocity V_{CD} when the

15 host vehicle is decelerated to accommodate the host vehicle to the preceding vehicle in the same manner as Fig. 11 and no delay process is carried out for the host vehicular velocity Vc. Since, in this case, actual inter-vehicle distance D becomes slightly shorter than target

20 inter-vehicle distance $D*_0$, difference value ?D of actual inter-vehicle distance D subtracted from target inter-vehicle distance $D*_0$ is small in the absolute value thereof and indicates negative. Hence, the deceleration request is delayed so as to provide the cause of the dull

25 response characteristic of deceleration control.

[0071] Fig. 13 shows a timing chart of (inter-vehicle distance priority target) acceleration/deceleration G_D in the preferred embodiment of Figs. 11A through 11C and (inter-vehicle distance priority target)

30 acceleration/deceleration G_{D0} of the comparative example as shown in Figs. 12A through 12C.

[0072] As appreciated from Fig. 13, at a time point immediately after the preceding vehicle has started the

deceleration, (inter-vehicle distance priority target) acceleration/deceleration G_D in the preferred embodiment is larger in the absolute value than inter-vehicle distance priority target) acceleration G_{D0} in the comparative example

5 and the response characteristic to the deceleration control gives a more favorable result.

[0073] On the other hand, at the latter half stage of deceleration control, the inter-vehicle distance priority target acceleration/deceleration G_D is smaller in its

10 absolute value than the (inter-vehicle distance priority target) acceleration G_{D0} in the comparative example and the response characteristic to the deceleration control gives a more favorable result.

[0074] On the other hand, at the latter half stage of

15 deceleration control, the inter-vehicle distance priority target acceleration/deceleration G_D is smaller in its absolute value than the (inter-vehicle distance priority target) acceleration/deceleration G_{D0} and the deceleration control is smoothly converged. In addition, it is not

20 necessary to enlarge the feedback gain in the preferred embodiment. Hence, there is no case where the acceleration/deceleration becomes excessively sensitive during the ordinary preceding vehicle following run so that the vehicular comfortability is worsened.

25 [0075] In the preferred embodiment, as the host vehicle velocity Vc becomes smaller, the delay is large. That is to say, the dead time to be added to the host vehicular velocity Vc becomes large. Hence, target inter-vehicle distance D* calculated from host vehicular velocity Vc

30 becomes large. Accordingly, the deceleration request becomes fast. As the host vehicular velocity Vc becomes lower, the initial response becomes more favorable. Hence, the deceleration characteristic which accommodates to the

driver's intention can be achieved.

[0076]   In addition, the initial response at the high speed is suppressed. No uncomfortable feeling is given to the host vehicular occupant during the high speed ran at which the deceleration is smooth. It is noted that the reverse effect to this fact appears in the same manner as the acceleration of the preceding vehicle, as described above.

[0077]   As described above, step S1 of calculation process shown in Fig. 2 and inter-vehicle distance sensor 12 are constituted by inter-vehicle distance detecting section. In the same way, step S3 of calculation process shown in Fig. 2 is constituted by host vehicle velocity detecting section. Step S15c of the calculation process shown in Fig. 4 is constituted by preceding vehicle velocity detecting section. The whole calculation process shown in Fig. 4 carried out at step S15 of calculation process shown in Fig. 3 is constituted by target inter-vehicle distance setting section. Step S6 of the calculated process shown in Fig. 2 is constituted by vehicular travel control section. Steps S15d to S15p of calculation process shown in Fig. 4 are constituted by delay providing section.

[0078]   Next, another preferred embodiment of the adaptive cruise control system according to the present invention will be described below.

[0079]   The structure of the vehicle in the other preferred embodiment is generally the same as that in the above-described embodiment. The calculation process to perform the preceding vehicle following control executed by adaptive cruise controller 20 is the same as the flowchart shown in Fig. 2. The detailed flowchart executed at step S5 of calculation process shown in Fig. 2. The detailed flowchart executed at step S5 of calculation process shown

in Fig. 2 is the same as shown in Fig. 3. The detailed flowcharts of steps S16, S18, and S19 are the same as those shown in Figs. 5, 6, and 7. The detailed flowchart of steps S15 of the calculation process shown in Fig. 3 is modified from Fig. 4 to Fig. 14. In the calculation process shown in Fig. 14, host vehicle velocity Vc calculated at step S3 of the calculation process of Fig. 2 is read at step S15s.

[0080]   At step S15s, adaptive cruise controller 20 reads host vehicle velocity Vc calculated at step S3 of calculation process of Fig. 2. At a step S15t, adaptive cruise controller 20 reads relative velocity Vr calculated at step S2 of the calculation process shown in Fig. 2. It is noted that, at the next step S15u, adaptive cruise controller 20 adds the host vehicular velocity Vc read at step S15s to relative velocity Vr read at step S15t to calculate preceding vehicle velocity V_F (V_F = Vc + Vr). At the next step S15v, adaptive cruise controller 20 searches a time constant T of a low-pass filter (LPF) in accordance with host vehicle velocity Vc read at step S15s using a control map shown in Fig. 15. In this embodiment, if the host vehicle velocity Vc is 0 Km/h, time constant T in this preferred embodiment indicates a predetermined value T_0 of the velocity. In addition, host vehicle velocity Vc is equal to or larger than 80 Km/h, time constant T in this embodiment indicates zero. During zero to predetermined time constant value T_0, as the host vehicular velocity Vc is increased the gradient of decrease is gradually reduced. Then, time constant T is set to be gradually reduced.

[0081]   At the next step S15w, adaptive cruise controller 20 calculated delay processed preceding vehicle velocity V_{FF} using time constant T set at step S15v by providing a delay process (low-pass filtering) for the preceding vehicle

velocity V_F calculated by step S15u. At a step S15x, adaptive cruise controller 20 multiplies delay processed preceding vehicle velocity V_{FF} by inter-vehicle velocity α and adds the multiplication result $V_{FF} \times \alpha$ to distance during the

5 vehicle stop β: $D*= V_{FF} \times \alpha + \beta$. It is noted that for inter-vehicle time duration α and distance during the vehicle stop β. It is noted that for inter-vehicle speed a and distance during the vehicle stop β, the values described in the BACKGROUND OF THE INVENTION are used.

10 [0082] A general description of the vehicular cruise control system by a plurality of calculation processes including such a calculation process as described above is the same as the first embodiment. On the other hand, target inter-vehicle distance $D*$ is calculated in

15 accordance with the calculation process of Fig. 14 carried out at step S15 of the calculation process of Fig. 3. In this calculation process, target inter-vehicle distance $D*$ using the preceding vehicle velocity V_F in principle is calculated. The delay processed preceding vehicle velocity

20 V_{FF} used for the calculation of target inter-vehicle distance $D*$ has a large delay as the host vehicle velocity becomes low. In details, as the host vehicular velocity Vc (since, at this time, the host vehicle is following the preceding vehicle, host vehicular velocity Vc is equal to or

25 substantially equal to preceding vehicle velocity V_F) becomes low, time constant T indicates a large value set in accordance with control map shown in Fig. 15 at step S15v of the calculation process of Fig. 14. Hence, delay processed preceding vehicle velocity V_{FF} to which the

30 low-pass filtering is carried out using time constant T often becomes largely delayed as either the host vehicle velocity Vc or preceding vehicle velocity V_F becomes low. It is noted that since time constant T is zero when host

vehicular velocity V_c is in excess of 80 Km/h, no delay
occurs with the low-pass filtering and delay processed
preceding vehicle velocity V_{FF} is substantially equal to
the preceding vehicle velocity V_F. In addition, delay

5 processed preceding vehicle velocity V_{FF} is substantially
equal to preceding vehicle velocity V_F. As described above,
the fact that delay processed preceding vehicle velocity
V_{FF} is delayed at a later time than actual preceding vehicle
velocity V_F means that the variation in target inter-vehicle

10 distance $D*$ is delayed even if the variation in preceding
vehicle velocity V_F due to the acceleration/deceleration
of the preceding vehicle (since the control time duration
is very short, the delay is slight). Hence, even in the
other preferred embodiment, the feedback control is carried

15 out so that actual inter-vehicle distance D is made
coincident with target inter-vehicle distance $D*$. Hence,
difference value $\triangle D$ between target inter-vehicle distance
$D*$ and actual inter-vehicle distance D is small in its
absolute value as compared with the case where no delay

20 occurs or indicates a negative value even if difference
value in nature indicates a positive value, or often
indicates a positive value even if the difference value
indicates a negative value. For example, even if actual
inter-vehicle distance D is long although target

25 inter-vehicle distance $D*$ becomes short due to the
deceleration of preceding vehicle, difference value $\triangle D$
of target inter-vehicle distance $D*$ subtracted from actual
inter-vehicle distance D which represents a positive value
means that it needs to shorten the inter-vehicle distance.

30 It is not yet necessary for the host vehicle to be decelerated
or it is not necessary for the host vehicle to be decelerated
so largely. However, difference value $\triangle D$ between target
inter-vehicle distance $D*$ and actual inter-vehicle distance

D is small in its absolute value, a value in an opposite direction, in other words, is negative value. At this time, it is necessary to maintain the inter-vehicle distance or elongate it. Hence, the deceleration request appears at

5 an earlier time. Consequently, the response characteristic of the deceleration control to the deceleration of preceding vehicle becomes favorable.

[0083] In a case where the preceding vehicle is accelerated, difference value ΔD of target inter-vehicle

10 distance D* indicates a negative value so that it becomes necessary to elongate actual inter-vehicle distance D if the negative value is continued. Hence, it is at least not yet necessary for the host vehicle to be accelerated or it is not necessary for the host vehicle to be accelerated

15 so largely eve if accelerated.

[0084] Whereas difference value ΔD between target inter-vehicle distance D* and actual inter-vehicle distance D is small in its absolute value or a value in the opposite direction to the original value, i.e., indicates a positive

20 value. This result makes the inter-vehicle distance maintained or makes it shortened. Hence, the acceleration request appears at an earlier timing. Consequently, the response characteristic of the acceleration control of the host vehicle to the acceleration of the preceding vehicle

25 becomes favorable.

[0085] Figs. 16A, 16B, and 16C show timing charts of (inter-vehicle distance priority target) acceleration/deceleration acceleration G_D, inter-vehicle distance D, target inter-vehicle distance D*, preceding

30 vehicle velocity V_F, and delay processed preceding vehicle velocity V_{FF} when the preceding vehicle is decelerated from 30 Km/h to 0 Km/h, i.e., to the vehicle stopped state in the same manner as Figs. 8A, 8B, and 8C. As shown in Figs.

16A through 16C, delay processed preceding vehicle velocity V_{FF} is largely delayed in the same manner as delay processed preceding vehicle velocity V_{FF}. On the other hand, since actual inter-vehicle distance D always indicates a smaller value than target inter-vehicle distance D*, difference value $\triangle$D of target inter-vehicle distance D* from actual inter-vehicle distance D indicates a negative value. At this time, since this results in a quick elongation of the inter-vehicle distance as described above, the deceleration request appears quickly. Consequently, the deceleration at the initial stage of control becomes large. The response characteristic of the vehicular deceleration control becomes favorable.

[0086]   Fig. 17 shows a timing chart of both of (inter-vehicle distance priority target) acceleration/deceleration G_D in the case of the other preferred embodiment shown in Fig. 16A and (inter-vehicle distance priority target) acceleration/deceleration G_{DO} in the case of the comparative example derived from Fig. 9A. These acceleration/deceleration G_D and G_{DO} are overlapped on the same graph in Fig. 17.

[0087]   As appreciated from Fig. 17, at a time immediately after the start of deceleration of the preceding vehicle. (inter-vehicle distance priority target) acceleration/deceleration G_D is larger than (inter-vehicle distance priority target) acceleration/deceleration G_{DO} in the case of the comparative example in thier absolute values and the response characteristic of deceleration control becomes more favorable. On the other hand, at the later half stage of deceleration control, acceleration/deceleration G_D in the case of the other embodiment, on the other hand, is smaller in its absolute value than (inter-vehicle distance priority target)

acceleration/deceleration G_{D0} in the case of the comparative example. The deceleration response characteristic of the deceleration control becomes more favorable. In addition, the delay is large as the host vehicle velocity Vc becomes

5 slow, in the other preferred embodiment. That is to say, since time constant T of low-pass filter carried out for preceding vehicle velocity V_F (or host vehicle velocity Vc) becomes large, a delay of target inter-vehicle distance D* thus calculated is large so that a deceleration request

10 accordingly becomes fast. As the host vehicular velocity becomes lower, the initial response becomes more favorable. Thus, the deceleration characteristic accommodated to the driver's intention is obtained. At the high speed run, the initial response is suppressed. No uncomfortable feeling

15 is given during the high speed run at which the deceleration is smooth. It is noted that the reverse effect appears during the deceleration of the preceding vehicle as described above. In addition, the same advantages can be obtained when the object to be processed under the low pass

20 filter is exchanged to the host vehicular velocity Vc.

[0088] As described above, inter-vehicle distance sensor 12 and step S1 of the calculation process of Fig. 2 constitute inter-vehicle distance detecting section. Step S3 of the calculation process of Fig. 2 is constituted by host

25 vehicular velocity detecting section. Step S15u of the calculation process of Fig. 14 constitutes the preceding vehicle velocity detecting section. The whole calculation process of Fig. 14 executed at step S15 of the calculation process of Fig. 3 constitutes target inter-vehicle distance

30 setting section. Step S6 of calculation process of Fig. 14 constitutes vehicular speed controlling section. Steps S15v and S15w of calculation process of Fig. 14 constitute delay providing section.

[0089]   It is noted that although, in each embodiment, the microcomputer is used for calculation processing devices, various types of logic circuits may be used in place of the microcomputer.   It is also noted that in place

5   of radar unit, photograph device such as CCD (Charge Coupled Device) camera and the inter-vehicle distance to the preceding vehicle may be derived from images photographing a host vehicular forward direction.

[0090]   The entire contents of a Japanese Patent

10   Application No. 2001-012432(filed in Japan on January 19,2001) are herein incorporated by reference. The scope of the invention is defined with reference to the following claims.

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